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Passaic Valley Sewerage Commissioners

Passaic Valley Sewerage Commissioners
Response to Request for Information
USEPA, Region 2

Item No. 10.e
PVSC Report

Document order #40

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GLeC

August 24, 1998

Great Lakes Environmental Center

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Mr. Felix Locicero
Team Leader
Fate and Effects Team
U.S. EPA Region II
290 Broadway
New York, NY 10007

RE: FINAL REPORT FOR THE STUDY ENTITLED "MONITORING AND MODELING OF NICKEL IN THE HACKENSACK AND PASSAIC RIVERS AND NEWARK BAY AND MONITORING AND DATA ANALYSIS FOR COPPER IN THE ARTHUR KILL AND KILL VAN KULL"

Dear Felix:

Enclosed is the Final Report addressing the nickel data collection effort and associated modeling for the Hackensack and Passaic Rivers and Newark Bay (Section One), and the copper data collection effort and re-evaluation of the need for TMDLs in the Arthur Kill and Kill Van Kull (Section Two). This report, along with the associated load response matrices for nickel in the Hackensack River/ Passaic River/Newark Bay system (provided separately) satisfies the New Jersey Harbor Dischargers Group Members' September 1, 1998 permit requirement for this report. We trust that you will coordinate with the New Jersey Department of Environmental Protection (which has also received this report) to acknowledge to the Harbor Dischargers Group that this requirement has been fulfilled.

If you have any questions regarding the information contained in this report or in the load response matricies, please do not hesitate to contact me at (616) 941-2230.

Sincerely,

G. M. DeGraeve
Director

Enclosures
cc: Robert Morrell - EPA Edison
     Tyler Linton - GLEC
     Robin Silva-Wilkinson - GLEC
     New Jersey Harbor Dischargers Group

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MONITORING AND MODELING OF NICKEL IN THE HACKENSACK AND PASSAIC RIVERS AND NEWARK BAY AND MONITORING AND DATA ANALYSIS FOR COPPER IN THE ARTHUR KILL AND KILL VAN KULL

TO

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

AND

U.S. ENVIRONMENTAL PROTECTION AGENCY REGION II

August 27, 1998

GLeC

Great Lakes Environmental Center

PREPARED BY:

GREAT LAKES ENVIRONMENTAL CENTER

IN ASSOCIATION WITH

HYDROQUAL, INC.

ON BEHALF OF:

THE NEW JERSEY HARBOR DISCHARGERS GROUP

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MONITORING AND MODELING OF NICKEL IN THE HACKENSACK AND PASSAIC RIVERS AND NEWARK BAY AND MONITORING AND DATA ANALYSIS FOR COPPER IN THE ARTHUR KILL AND KILL VAN KULL

BACKGROUND

In 1990, the area encompassing the New York/New Jersey Harbor (NY/NJ Harbor) was declared impaired by the U.S. Environmental Protection Agency (USEPA) under the provisions of the Clean Water Act, due to water-quality criteria metal exceedances which were projected from an EPA-developed water quality model. The water quality model, developed from surveys of the New York and New Jersey tributaries, projected that four metals (mercury, lead, nickel, and copper) would exceed water quality criteria in the three primary New Jersey tributaries to the Harbor. However, the New Jersey component of the survey was conducted using techniques which did not produce a sufficient amount of high quality data for the metals in question, resulting in a model that was not well calibrated for the New Jersey Tributaries. Consequently, a data collection and analysis effort was performed in 1995 to determine which metals were in fact present in the New Jersey portion of the Harbor at concentrations in excess of water quality standards (WQS). The Arthur Kill was not included in that component of the investigation, but total recoverable nickel and lead, and dissolved copper were projected by the model to exceed WQS in the Arthur Kill.

The New Jersey Harbor Dischargers Group (NJHDG) funded a data collection and analysis effort to determine which metals and tributaries would require additional monitoring and modeling, and to better understand the ambient concentrations of the metals of concern. All sample collections and analyses for this investigation were performed using "clean techniques." The results showed that mercury and nickel were the only metals found to be present at concentrations which resulted in projected water quality criteria exceedences. Mercury was determined to be a ubiquitous problem, and EPA determined that further mercury investigations were not appropriate at that time. Nickel was found to be present at concentrations exceeding the WQS in the Hackensack River and to be present at concentrations approaching the ambient water quality criteria in the Passaic River.

A further investigation of the ambient concentrations of nickel in the Hackensack and Passaic River systems and Newark Bay, and the development of a water quality model for nickel in those

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systems was identified as a need based upon the initial NJHDG investigation, which is the subject of this report.

Also presented in this report are the results of an investigation of the Arthur Kill, which was completed to determine whether dissolved copper is present or is projected to be present at concentrations in excess of WQS. Although total recoverable nickel and total recoverable lead concentrations in the Arthur Kill were also projected to exceed WQS, calculations of the dissolved concentrations of those metals in the Arthur Kill have demonstrated that they do not exceed dissolved water quality standards.

This report is composed of two sections, Section One consists of the data obtained in the monitoring of nickel and associated parameters in the Passaic River/Hackensack River/Newark Bay, plus a description of the nickel model development and calibration; Section Two consists of a presentation of the copper-related data for the Arthur Kill/Kill Van Kull and a re-evaluation of the need for TMDLs for copper in that area of the Harbor.

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SECTION ONE: MONITORING AND MODELING OF NICKEL IN THE HACKENSACK AND PASSAIC RIVERS AND NEWARK BAY

OBJECTIVES AND SCOPE OF WORK

Water Quality Monitoring in the Hackensack and Passaic River Systems and Newark Bay

The nickel monitoring study was designed to provide data which were used to develop and calibrate a water quality model for nickel in the Hackensack and Passaic River systems. Temporal distributions (over a ten month period) of water column dissolved and total recoverable nickel concentrations and associated parameters were obtained under wet and dry meteorological conditions at three stations in the Hackensack River, three stations in the Passaic River, one station in Newark Bay, and one station at the southern mouth of Newark Bay, for a total of eight ambient water sampling stations (**Figure 1-1**; stations K1 and K2 on Figure 1-1 were associated with the copper ambient sampling program). Samples were also collected from the Oradell dam on the Passaic River and the Dundee dam on the Hackensack River.

In addition, sevem Combined Sewer Overflows (CSOs) and nine Stormwater Outfalls (SWOs) discharging to the Hackensack and Passaic Rivers were monitored (see Figure 1-1), as well as the effluent from three municipal wastewater treatment plants (the Bergen County Utilities Authority, the North Bergen municipal wastewater treatment plant, and the Secaucus municipal wastewater treatment plant) discharging to the Hackensack River. There are no municipal wastewater treatment plants discharging to the Passaic River below the Dundee dam, therefore, there were no POTWs discharging to the Passaic River to be monitored. Samples were also collected once from the tributaries to the Passaic River (the Saddle River) and the Hackensack River (Overpeck Creek, Berry's Creek, and Kingsland Creek) to screen for nickel sources.

These general objectives were the basis for the following specific project goals:

- To obtain dissolved and total recoverable nickel; total organic, dissolved organic and particulate carbon (TOC/DOC/PC); and total suspended solids (TSS) data for the eight ambient water sampling stations. One dry weather survey was conducted each month for six months (May to October 1997).
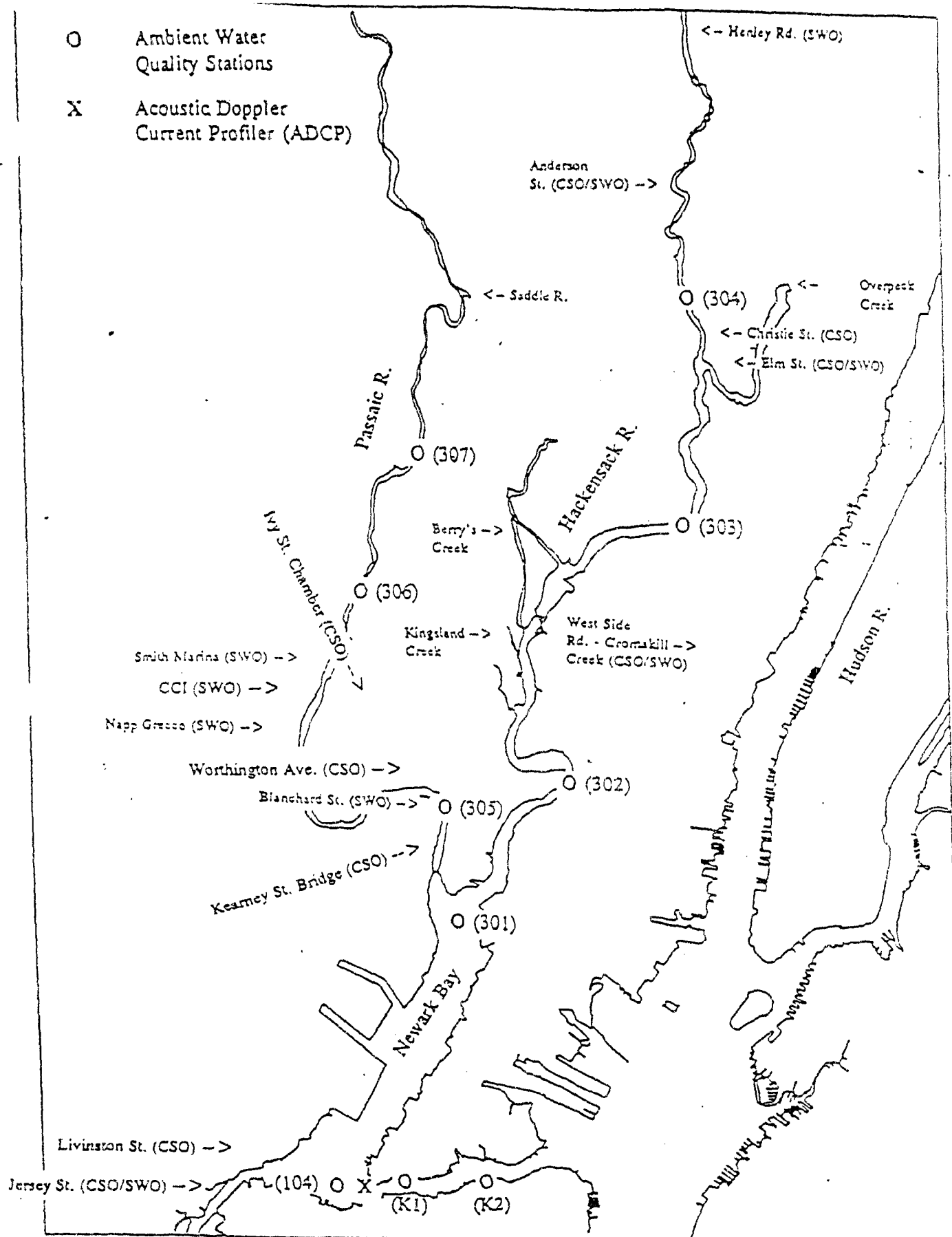
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Figure 1-1. Location of sampling stations for the nickel-related sampling program

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- The same parameters described above were measured under wet conditions three times over the course of the study at the eight ambient water sampling stations. The three surveys were initiated within 48 hours of the termination of a precipitation event in which ¼ inch or more of rain was recorded at Newark International Airport. Each survey involved three days of sampling: two samples were collected per day at each station, separated by a minimum of six hours, regardless of whether or not the precipitation continued.

- The water column at the eight ambient water sampling stations was characterized during the nine (6 dry-weather and 3 wet-weather) sampling events using profiling sensors to collect salinity, dissolved oxygen, temperature, and pH data.

- Water column variations throughout a tidal cycle were also characterized. In July 1997, three samples were collected during a tidal cycle (near maximum flood and ebb, minimum high and low slack water) at ambient water sampling stations 301, 303, and 306 (see Figure 1-1).

- Dissolved and total recoverable nickel, TOC/DOC/PC, and TSS data were collected for samples collected from the discharge of the Oradell and Dundee dams in the Hackensack and Passaic Rivers, respectively. Samples were collected bi-weekly from each dam over the six month study period, concurrent with the ambient wet and dry weather water sampling events when that was possible.

- Dissolved and total recoverable nickel, TOC/DOC/PC, and TSS data were collected for CSO and SWO discharges to the rivers during storm events over the course of the monitoring study. Sampling of the CSOs commenced when a storm reached an intensity sufficient to cause the regulator to divert flow from the treatment plant to the river. Sampling of the SWOs commenced when at least ¼ inch of precipitation had fallen. The initial samples for each event were composited with samples collected every 15 minutes for one to two hours, if possible.

- Dissolved and total recoverable nickel, DOC/POC/PC, and TSS data were collected for the three municipal wastewater treatment plant (POTW) effluents being discharged to the Hackensack River. One effluent sample was collected per month from each POTW, and bi-weekly samples were collected from the Bergen County Utility Authority POTW in May and June 1997.

- Total recoverable nickel data were obtained for samples collected from tributaries to the Passaic River (Saddle River) and the Hackensack River (Overpeck, Berry's, and Kingsland creeks). The samples were collected at the same time as the initial ambient water samples were collected.

- Bottom sediment characteristics were determined from sediment samples collected from seven of the eight ambient water sampling locations. A single sample was collected from each site, and the surface (0-5 cm) sediment layer was analyzed for whole sediment nickel, acid volatile sulfide and simultaneously extracted metals (AVS/SEM), sediment grain size, and TOC. The porewater was analyzed for nickel, salinity, pH, DOC, and sulfide.

All of the relevant sample collection and preservation procedures, as well as the analytical procedures and requirements were outlined in the Quality Assurance Project Plan for this study (dated April 10, 1997), which was approved by EPA Region II.

The data collected to meet the objectives outlined above are presented in Tables 1-1 through 1-7 of this report. This information was utilized to develop a water quality model for nickel for the Hackensack River/Passaic River/Newark Bay system (see below). This water quality model and the associated load response matricies (which have been provided to EPA Region II and the New Jersey Department of Environmental Protection in the form of a computer disk), provides EPA with the necessary mechanism to develop TMDLs for nickel (if needed).

Model Development and Calibration

The fate of nickel in the Hackensack/Passaic Rivers has been quantified through the use of a calibrated mathematical water quality model. The basis for the water quality model implemented in

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TABLE 1-1.   TOTAL AND DISSOLVED (in parentheses) NICKEL CONCENTRATIONS FROM THE MUNICIPAL WASTEWATER TREATMENT PLANT MONITORING FROM MAY, 1997 THROUGH OCTOBER, 1997. ALL CONCENTRATIONS ARE REPORTED IN μg/L.

| | Month Sampled | | | | | |
	May 97'	Jun 97'	Jul 97'	Aug 97'	Sep 97'	Oct 97'
Total & (dissolved) Nickel[a]						
N. Bergen	L(L)	3[b](L)	L(L)	26(L)	2(L)	2(2)
Secaucus	L(L)	L[b](2)	L(L)	L(L)	3(2)	2(L)
Bergen Co.[c]	17(21)-20(22)	16(16)-12[b](10)	16(18)	12(10)	29(25)	19(18)
Re-Analysis[d]	16.7(16.1)-22.2(18.5)	16.3(20.9)	15.2(17.3)			

[a] L= reporting limit of 2 μg/L.

[b] Indicates samples analyzed for the purpose of QA/QC.

[c] Values separated by a dash indicate the concentrations of bi-weekly samples for the same month.

[d] Re-Analysis of same sample by Battelle Ocean Sciences.

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TABLE 1-2. TOTAL AND DISSOLVED (in parentheses) NICKEL CONCENTRATIONS FROM THE AMBIENT DRY WEATHER MONITORING UPSTREAM MONITORING AND TRIBUTARY MONITORING FROM MAY, 1997 THROUGH OCTOBER, 1997.

	Total & (dissolved) Nickel (μg/L)[a,b]					
River/Bay & Site	May 97'	Jun 97'	Jul 97'	Aug 97'	Sep 97'	Oct 97'
Passaic River						
Dundee Dam[c]	L(L) - L(L)	L(L) - 3(2)	L(L) - L(L)	3(L)	3(L) - 3(L)	L(L) - L(L)
Upst. Dundee Dam	---	---	---	L(L)	---	---
Saddle River	L(L)	---	---	---	---	---
Station 307	3(L)	4(L)	3(L)	L(L)	2(L)	L(L)
Station 306	L(L)	7(L)	4(3)	16(L)	11(L)	3(L)
Re-Analysis[e]				15.2		
Station 305	L(L)	L(3)	2(L)	9(L)	7(5)	L(L)
Re-Analysis[e]		2.97(2.66)				
Hackensack River						
Oradell Dam[c]	L(L) - L(L)	L(L) - L(L)	L(L)	L(L)	L(L) - L(L)	L(L) - L(L)
Upst.Oradell Dam	---	---	---	L(L)	---	---
Overpeck Creek	7(7)	---	---	---	---	---
Berry's Creek	3(4)	---	---	---	---	---
Re-Analysis[e]	0.9(L)					
Kingland Creek	L(3)	---	---	---	---	---
Re-Analysis[e]	1.1(3.8)					
Station 304	5(4)	11*(5*)	6(L)	10(6)	11(8)	8(6)
Station 303	6(5)	7(6)	5(7)	7(5)	8(6)	7(6)
Re-Analysis[e]			5.1			
Station 302	L(3)	L(L)	5(4)	L(L)	4(L)	2(2)
Re-Analysis[e]	L(2.47)					
Newark Bay						
Station 301	L*(L*)	3(L)	4(L)	L(L)	4(L)	L(L)
Station 104	L(L)	L(L*)	L(L)	L(L)	L(L)	L(L)

[a] L = reporting limit of 2 μg/L;
[b] Surface water quality standard for dissolved nickel = 8.2 μg/L.
[c] Values separated by a dash indicate the concentrations of bi-weekly samples for the same month.
[d] Re-Analysis of same sample by Battelle Ocean Sciences
[e] Indicates samples analyzed for the purpose of QA/QC.

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TABLE 1-3. TOTAL AND DISSOLVED (in parentheses) NICKEL CONCENTRATIONS FROM THE AMBIENT WET WEATHER MONITORING FROM NOVEMB. , 1997 THROUGH FEBRUARY, 1998 [a,b].

River/Bay & Site	Event #1 - November 97'			Event #2 - December 97'			Event #3 - February 98'		
	24th	25th	26th	12th	13th	14th	7th	8th	9th
Passaic River									
Dundee Dam						L(L)[c]			L(L)[c]
Station 307	L(L)	L(L)	2(L)	2(L)	L(L)[d]	L(L)	L(L)[d]	L(L)[d]	L(L)[d]
					L(L)		L(L)	L(L)	L(L)
Station 306	3(L)	L(L)[d]	4(L)	L(L)	4(L)[d]	4(L)	13(L)[d]	L(L)[d]	L(L)[d]
		3(L)			3(L)		L(L)	L(L)	L(L)
Station 305	L(L)	L(L)[d]	L(L)[d]	L(L)[d]	L(L)[d]	L(L)[d]	12(L)[d]	L(L)	L(L)
		L(L)	L(L)	L(L)	L(L)	10(L)	L(L)		
Hackensack River									
Oradell Dam						L(L)[c]			L(L)[c]
Station 304	8(6)	4(2)	10(6)[d]	12(10)[d]	11(10)[d]	11(9)[d]	3(3)[d]	3(3)[d]	5(5)[d]
			5(3)	7(5)	8(5)	7(4)	5(L)	5(2)	L(L)
Station 303	9(8)	6(6)	10(9)[d]	8(7)[d]	7(6)[d]	7(6)[d]	8(7)[d]	5(5)[d]	5(4)[d]
			14(12)	10(9)	13(9)	10(8)	7(5)	7(6)	5(5)
Station 302	4(4)	4(4)	4(4)[d]	L(L)[d]	L(L)[d]	L(L)[d]	4(3)[d]	L(L)[d]	L(L)[d]
			5(4)	6(3)	5(5)	6(4)	L(L)	5(3)	L(L)
Newark Bay									
Station 301	L(L)	L(L)[d]	L(L)[d]	L(L)[d]	L(L)[d]	L(L)[d]	L(L)[d]	L(L)[d]	L(L)[d]
		L(L)	L(L)	L(L)	L(L)	L(L)	L(L)	L(L)	L(L)
Station 104	L(L)[d]	L(L)[d]	L(L)[d]	L(L)[d]	L(L)[d]	L(L)[d]	L(L)	L(L)[d]	L(L)[d]
	L(L)	L(L)	L(L)	L(L)	L(L)	L(L)		L(L)	L(L)

[a] L = reporting limit of 2-3 μg/L.

[b] Surface water quality standard for dissolved nickel = 8.2 μg/L.

[c] Sample taken on 12/15/97.

[d] Values directly above and below one another are the concentrations of consecutive morning and afternoon samples, respectively, from the same day.

[e] Sample taken on 2/10/98.

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TABLE 1-4. TOTAL AND DISSOLVED (in parentheses) NICKEL CONCENTRATIONS FROM THE CSO SAMPLING FROM JULY, 1997 THROUGH FEBRUARY, 1997.

Site	Date Sampled				
	24 Jul 97	14 Nov 97	22 Nov 97	2 Feb 98	23 Feb 98
	Total (Dissolved) Nickel ($\mu g/L$)[*]				
Livingston St.	8(3)				
Worthington Ave.	16(L)				
Ivy St. Chamber	6(4)				
Kearney St. Bridge	L(L)		L(L)		
Christie St.	7(L)				
Elm St.	L(L)	8(7)	13(9)		
Court St.	L(L)		7(L)	L(L)	L(L)
West Side Rd.		6(5)	3(L)		4(3)
Anderson St.					L(L)

[*] L = reporting limit of 2-3 $\mu g/L$.

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TABLE 1-5. TOTAL AND DISSOLVED (in parantheses) NICKEL CONCENTRATIONS FROM THE SWO SAMPLING FROM JULY, 1997 THROUGH FEBRUARY, 1998.

Site	Date Sampled				
	24 Jul 97	14 Nov 97	22 Nov 97	2 Feb 98	23 Feb 98

Total (Dissolved) Nickel (μg/L)[a]

Site	24 Jul 97	14 Nov 97	22 Nov 97	2 Feb 98	23 Feb 98
CCI	12(5)	L(L)		5(3)	
NAPP-Greco	3(L)	13(L)		17(L)	4(L)
Smith Marina	16(9)	29(L)			
E. Jersey St.	L(L)		L(L)	6(L)	4(L)
Blanchard St.	L(L)	4(L)			
Elm St.	L(L)	9(6)	L(L)	L(L)	L(L)
Henley Rd.	L(L)		L(L)	L(L)	L(L)
Anderson St.	8(8)			L(L)	L(L)
West Side Rd.		7(4)	4(4)		15(13)

[a] L= reporting limit of 2-3 μg/L.

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TABLE 1-6. TOTAL AND DISSOLVED NICKEL CONCENTRATIONS FROM THE DRY WEATHER TIDAL SAMPLING EVENT PERFORMED IN JULY 1997.

Bay/River & Site	Total and (dissolved) Nickel (μg/L) [a]		
	Morning	Mid-Afternoon	Late Afternoon
Newark Bay (301)			
Bottom	L(L)	L(L)	L(L)
Surface	L(3)	L(L)	4(3)
Hackensack River (303)			
Bottom Re-Analysis [b]	6(8) 2.65(8.64)	7(7) 3.05(7.03)	10(12) 3.46(7.69)
Surface Re-Analysis [b]	8(8) 4.84(9.04)	7(8) 3.34(7.23)	9(10) 4.24(5.26)
Passaic River (306)			
Bottom Re-Analysis [b]	5(L)	3(L)	5(4) 4.83(2.63)
Surface	3(L)	L(L)	4(4)

[a] L = Reporting Limit of 2 μg/L.
[b] Re-Analysis of same sample by Battelle Ocean Sciences

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TABLE 1-7.   NICKEL CONCENTRATIONS AND ASSOCIATED PARAMETERS IN SEDIMENT AND SEDIMENT POREWATER FROM THE HACKENSACK / PASSAIC RIVERS SAMPLED FEBRUARY 1998.

Site	Porewater Ni (μg/L)	Total Ni (μg/g)	SEM* Ni (μg/g)	SEM* Ni (μmol/g)	AVS[b] (μmol/g)
302	5.97	6.6	1.59	0.0271	00.8
303	5.66	47.4	6.14	0.1050	83.8
304	10.1	24.5	3.06	0.0522	13.5
305 (Lab Duplicate)	3.79	44.1	6.97	0.1185	45.3
306 (Field Duplicate)	19.4	57.1	8.47	0.1445	26.1
307	3.11	25.6	7.74	0.1320	17.3

[a] SEM Ni denotes the nickel associated with metal sulfides.
[b] Acid volatile sulfides.

this study is the Chemical Transport and Analysis Program (CTAP) developed by HydroQual, Inc. in 1982, and revised in 1991. CTAP is the model of choice for the WLA determination because of its capability to correctly simulate the complex transport, kinetic processes, and geophysical morphology of the New Jersey tributaries.

CTAP uses the principles of mass balance to obtain a steady-state solution to a series of linear differential equations. Terms included in the differential equations account for:

advective/dispersive transport
solid phase vertical transport
phase partitioning and kinetic reactions
transport across the water column/sediment interface
transport across the air/water interface
point and nonpoint source loading

The CTAP model framework for this study consists of 91 water column segments plus an additional 91 sediment segments. The spatial domain of the model includes the Hackensack River from the Oradell Dam, the Passaic River from Dundee Dam, Newark Bay, Kill Van Kull and the Arthur Kill. A schematic of the model segmentation is shown in Figure A-1 of Appendix A.

Advective-Dispersive Transport

The physical transport used in CTAP is based upon model calibration of observed salinity measurements collected during the period May 1997 through February 1998. Model coefficients (dispersion coefficient) have been adjusted to reproduce the observed data. Fresh-water inputs to the model were obtained from USGS data at gaging stations located above the heads of tide of the Hackensack and Passaic Rivers. Volumetric loadings dependent upon precipitation within the model domain, storm water runoff and combined sewer overflows, were computed using the Rainfall Runoff Modeling Program (RRMP; Hydroscience, 1978), which has been incorporated into CTAP.

To compute the volume of runoff reaching the harbor for a given period of time, RRMP requires a user-specified rainfall. To define rainfall for the calibration, the average daily rainfall observed for the calibration period at the NOAA National Climatic Data Center at the Newark International Airport

was used. Specifically, for the period April 1, 1997 through February 28, 1998, the average precipitation was 0.12 inches per day.

Flow inputs to New York/New Jersey Harbor from industrial and municipal point sources were based upon data furnished by EPA Region II and the New Jersey Harbor Discharges Group. In a manner consistent with the determination of rainfall volume, an average of the daily flow records for the calibration period was used for each municipal and industrial (where possible) discharge.

Longitudinal dispersion coefficients were adjusted to reproduce salinity data collected during the calibration period. The salinity calibrations are reasonable, and serve as verification of the CTAP advective and dispersive transport fields. Model and data comparisons for salinity may be found in **Figures A-2 and A-3 of Appendix A. Figures A-2 and A-3** show calculated and observed salinity along three spatial transects: the Hackensack River and Newark Bay, the Passaic River, and the Kills.

Solid Phase Vertical Transport

In addition to longitudinal advective and dispersive transport, CTAP allows for the specification of solid phase vertical transport. Solid phase vertical transport includes: water column settling, settling from the water column to the bed, resuspension from the bed to the water column, and burial of bed solids. Solid phase vertical transport rates were determined through calibration to suspended solids data collected during the calibration period. The settling velocity (or rate at which particulate matter drops through the water column), and the net resuspension rate were set to reproduce the observed suspended solids data. For the calibration period, on an average mass basis, the amount of solid phase material leaving the water column and entering the bed is equal to the amount of solid phase material that is resuspended from the bed to the water column. Spatial profiles of calculated and observed suspended solids concentrations are shown on **Figures A-4 and A-5 of Appendix A.**

It is important to recognize that at some locations in the Hackensack and Passaic Rivers, there is a large variability with the TSS data. This variability may be attributed, to a large degree, to sporadic re-suspension events. These events, however, are not regarded as significant for calculating nickel concentrations in the water column, particularly dissolved nickel concentrations. In a previous study (HydroQual, Inc., 1995), it was demonstrated that re-suspension events may temporarily increase total recoverable metal concentrations, but have little effect on dissolved metal, which is the form of concern in this situation. Overall, the calculated TSS concentrations are in good agreement with observed data.

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Kinetic Processes

One of the major characteristics which differentiates metals from classical water quality variables is their affinity to adsorb to, and desorb from, particulate material. Therefore, dissolved and solid phase constituents are subject to phase change, or reversible adsorptive/desorptive processes. Within the CTAP model framework, the rates of adsorption and desorption relative to one another are defined by a partition coefficient. The partition coefficient is the metal-specific ratio of the solid phase metal to the dissolved phase metal. The water column partition coefficient is expressed such that the dissolved metal concentration is specified on a bulk volume basis (microgram per liter of water column), and the particulate metal concentration is specified on a solids mass basis, (microgram per kg of suspended solids). In this manner, for a given partition coefficient and quantity of total recoverable metal, the amount of metal in the dissolved and in the particulate forms is dependent upon the suspended solids concentration.

It can be shown from standard partitioning theory that the fraction of dissolved metal (f_d) is related to the solids concentration (m) and the partition coefficient (π) through the following equation:

$$f_d = \frac{1}{1 + \pi m} \tag{1-1}$$

Rearranging equation 4-1 in logs:

$$\log (1/f_d - 1) = \log \pi + \log m \tag{1-2}$$

or

$$\log (1/f_d - 1) - \log m = \log \pi \tag{1-3}$$

Therefore, for measurements of metal where the dissolved concentration, total recoverable concentration, and solids concentration are known, the partition coefficient, π, can be calculated through equation 1-3. Using average fraction dissolved values and solids concentrations for nickel, the average partition coefficient is calculated. In a previous Harbor WLA effort, a partition coefficient of 41,000 was calculated. New data collected in this study confirm the nickel partition coefficient of 41,000 for Newark Bay and the Passaic River. However, the data obtained in this study for the Hackensack River show different partitioning characteristics; the new data show that the nickel partition coefficient varies along the Hackensack River from 11,600 to 22,500.

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Similar to the water column partition coefficient, CTAP requires a user-specified sediment partition coefficient. For this study area, sediment partition coefficients were determined based on the findings of the sediment survey performed as part of this effort. To simulate the binding capacity of the reactive pool of acid volatile sulfides found to be present in the sediments in the study area, sediment partition coefficients were set to very high values for all metals. In effect, all bed metals were fixed into the particulate form.

Nickel Calibration

The advective-dispersive transport, the solid phase vertical transport and the partitioning characteristics (kinetics) have been incorporated into the CTAP framework to compute total recoverable and dissolved nickel concentrations. Loads were computed from flow data and measured nickel concentrations from POTWs, CSOs SWOs, and tributary head-waters. Model results have been compared to ambient nickel data collected between May 1997 and February 1998 on Figures A-6 and A-7 of Appendix A for total recoverable nickel, and Figure A-8 and A-9 of Appendix A for dissolved nickel. The model comparisons verify the model's ability to simulate nickel concentrations in the Hackensack and Passaic Rivers.

Determination of Target Concentrations

An issue of concern in the development of this model is that the dissolved water quality criterion for nickel (8.2 μg/L) is based on one in three-year exceedances while the results of the steady-state model calculates long-term average concentrations. Therefore, a methodology has been formulated to convert one in three-year exceedance criteria to target long-term average concentrations. The criterion for nickel is based on chronic toxicity of dissolved metal. The chronic criteria are expressed as a one in three-year exceedance of four-day averages. Therefore, chronic criteria correspond to a compliance frequency of 99.63 percent of the time.

Probability distributions of ambient nickel data have been developed for the Hackensack and Passaic Rivers based upon the data collected during 1997 and 1998. The probability distributions are shown on Figure A-10 of Appendix A. In order to determine long-term average target concentrations, these distributions have been shifted downward, keeping the variability (slopes) constant until compliance is met at the appropriate percentile (99.63 percent for chronic toxicity). The mean of the

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new distribution, therefore, has become the target long-term concentration. Since these distributions are log-normal, the arithmetic mean of the distribution has been calculated as follows:

$$\bar{u} = \exp(\mu_{ln} + 1/2 \ \sigma_{ln}^2)$$

where:

$\bar{u}$ = arithmetic mean

μ_{ln} = ln mean of the distribution

σ_{ln}^2 = ln variance of the distribution

The target long-term average concentrations in the Hackensack and Passaic Rivers are, therefore, the arithmetic mean ($\bar{u}$) calculated based upon the methodology given above.

In a previous TMDL/WLA development for the New York - New Jersey Harbor (HydroQual, Inc, 1995), the standard deviation of the observed data was assumed to be constant for projection scenarios. This assumption is conservative and is reasonable when considering the many different source categories which affect the open Harbor waters. In the Hackensack River, however, municipal point sources (particularly The Bergen County Utilities Authority) are a major influence on receiving water nickel concentrations. In the development of a TMDL/WLA, these point sources may require reductions to meet water quality criteria. In reducing point source concentrations, it is also reasonable to assume that a source of variability will also be reduced; therefore, the standard deviation of the distribution should also be reduced.

The observed ln standard deviation for the 1997-98 Hackensack River sampling data is 0.5, with an arithmetic mean of 5.44 ug/L. Hypothetically, if all municipal point sources were to be removed from the Hackensack River, it may be assumed that the resulting variability would resemble the variability observed in the Passaic River, which is not influenced by municipal point sources. The ln standard deviation of the data obtained in this study for the Passaic River is 0.39, with an arithmetic mean of 2.05 ug/L. Therefore, it is assumed that as municipal point source concentrations are reduced, the standard deviation will be reduced from 0.5 to approximately 0.39.

In order to implement this concept, a linear interpolation of the standard deviation has been developed as a function of the mean nickel concentrations calculated by the model. The linear interpolation is as follows:

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$$\text{Std. Dev.} = 0.33\,\mu + 0.32$$

$$\text{where: } \mu = \text{mean nickel calculation}$$

Using the computed standard deviation based on the projected mean concentration, a new long-term average target concentration has been computed, as discussed above. Therefore, for each management scenario evaluation, using the load response matrix discussed in the next section, the long-term average target concentrations will be automatically re-calculated for the Hackensack River. The target concentrations will remain constant for other locations in the study area.

TMDL/WLA Development

The calibrated model discussed in the previous section can be used to determine TMDL/WLS for the Hackensack/Passaic Rivers. WLAs are allocated to point sources while LAs (Load Allocations) are allocated to nonpoint sources (such as atmospheric deposition). TMDLs can be expressed on a system-wide, region-specific, or segment-specific basis. However, many WLAs and/or LAs are possible for the same TMDL. To facilitate the task of developing WLAs, a spreadsheet summarizing model results has been developed for use by NJDEP and EPA Region II, and has been provided in the form of a computer disk associated with this report.

The calibrated nickel model has utility for forecasting ambient conditions under different loading scenarios. For this effort, an October low flow transport field was chosen for projection purposes. This is the same transport field that was used in the original 1995 TMDL/WLA effort. Loadings in this transport field were slightly altered so that all municipalities would be discharging at design flows, and all industries at permit flows. Since the behavior of nickel in the receiving waters is linear, the model may be used to perform unit responses for each loading source or category. That is, each load may be simulated separately to give individual responses. Since the model is also linear, the sum of the individual responses will equal the total response.

Therefore, individual unit responses were performed, and the results were placed in an Excel spreadsheet. The spreadsheet allows for user-specified concentrations for loads by source, and for projection of ambient conditions under user-specified conditions, eliminating the necessity of running the model for each projection case. In summary, the spreadsheet allows NJDEP and EPA to perform management scenarios and develop TMDLs and WLAs.

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SECTION II: A RE-EVALUATION OF THE NEED FOR TMDLs FOR COPPER IN THE ARTHUR KILL AND KILL VAN KULL

OBJECTIVES AND SCOPE OF WORK

Water Quality Monitoring in the Arthur Kill

The investigation of dissolved copper in the Arthur Kill was designed to enhance the existing data base for water column chemistry in the Hackensack/Passaic Rivers and Arthur Kill/Kill Van Kull, and to better understand the concentrations of copper in the point source discharges to the Kills. Temporal distributions (over a ten month period) of water column dissolved copper concentrations and associated parameters were measured three times under wet and six times under dry meteorological conditions at two sampling stations in the Arthur Kill, and two stations in the Kill Van Kull (for a total of four ambient water sampling stations **Figure 2-1**). The municipal effluents being discharged to the Arthur Kill (Joint Meeting, Linden Roselle and Rahway Valley) were sampled monthly, and the samples were analyzed for total recoverable copper. In addition, two CSOs and one SWO discharging to the Arthur Kill were monitored concurrent with the Passaic and Hackensack River/Newark Bay sampling events (**Figure 2-1**).

The general objectives of this component of the program were:

- To obtain total and dissolved copper; total organic, dissolved organic and particulate carbon (TOC/DOC/PC); and total suspended solids (TSS) data for the four ambient water sampling stations. One dry weather survey was conducted each month for six months (May to October 1997).

- The same parameters described above were measured under wet conditions over the course of the study at the four ambient water sampling stations. The survey was initiated within 48 hours of a precipitation event in which ¼ inch or more of rain was recorded at Newark International Airport. The survey involved three days of sampling: two samples were collected per day at each station, separated by a minimum of four hours, regardless of whether the precipitation continued.

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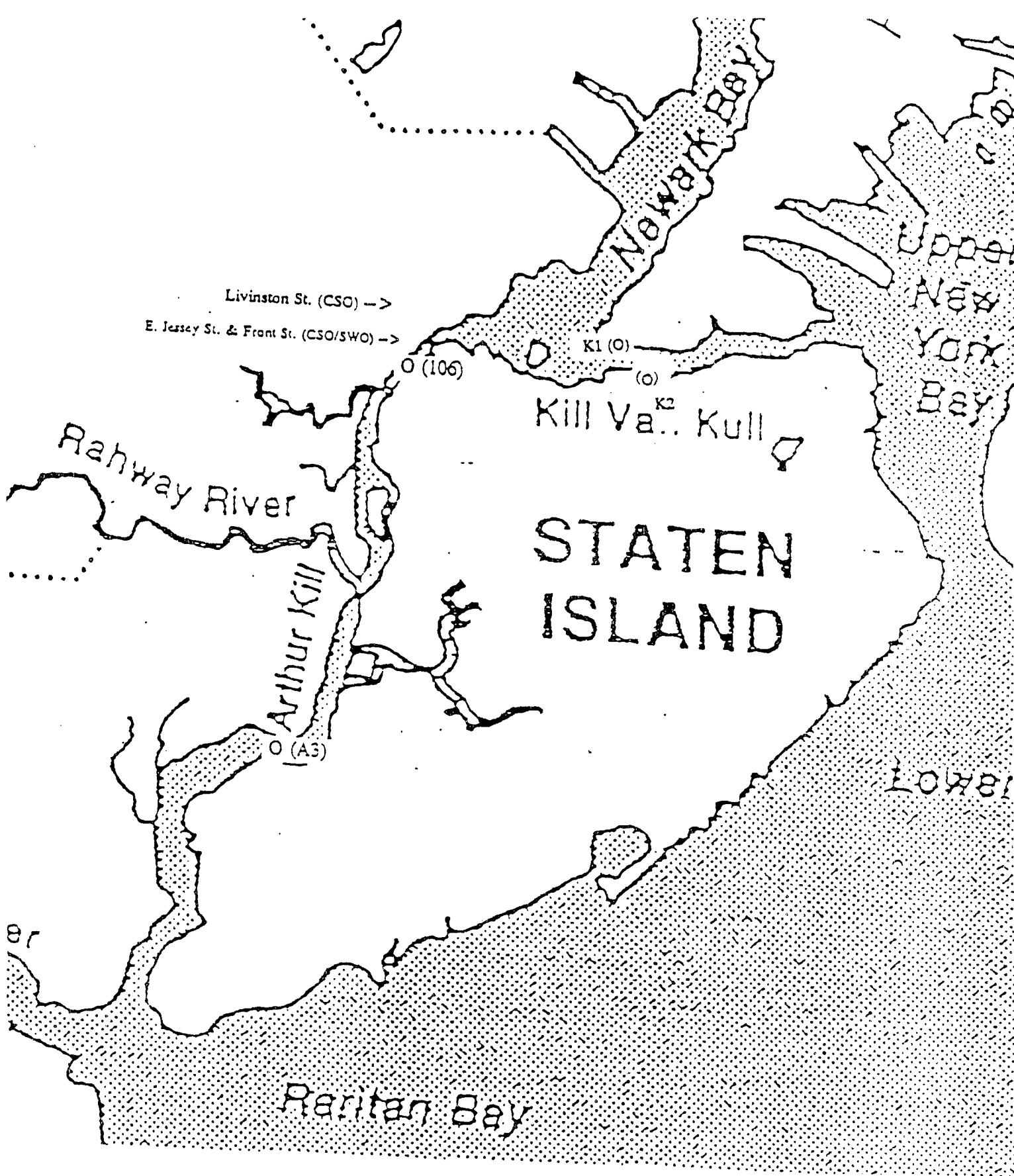
Figure 2-1.   Location of sampling stations for the Arthur
Kill/Kill Van Kull metals sampling program

- To characterize the water column at the four ambient water sampling stations during the nine (6 dry-weather and 3 wet-weather) sampling events using profiling sensors of salinity, dissolved oxygen, temperature, and pH.

- To obtain dissolved and total recoverable copper, TOC/DOC/PC, and TSS data for CSO and SWO discharges to the Arthur Kill during storm events over the course of the monitoring study. Sampling of the CSOs commenced when the storm reached an intensity sufficient to cause the regulator to divert flow from the treatment plant to the river. Sampling of the SWO was initiated when at least ¼ inch of precipitation had fallen, and the initial sample was composited with samples collected every 15 minutes for two hours.

- To obtain total recoverable copper, TOC/DOC/PC, and TSS data for three POTW effluents being discharged to the Arthur Kill (Linden Roselle, Rahway Valley and Joint Meeting). One effluent sample was collected per month, within one day of the ambient water sampling event, for each of the treatment plants.

The data collected to satisfy the objectives discussed above are presented in Tables 2-1 through 2-5, which were used to evaluate the need for a TMDL for copper in the Arthur Kill/Kill Van Kull.

Historical Overview

The original (1991) ambient data evaluation projections and the modeling evaluation projections that were performed to determine if there are potential copper criterion exceedances in the Arthur Kill and Kill Van Kull (The Kills) were not in agreement; statistical data evaluations of the ambient data did not show potential exceedances, while model projections indicated potential exceedances. Measurements of copper in the Kills did not indicate a criterion exceedance, since there was no single observation that was in excess of the copper criterion. Furthermore, a statistical projection based upon the copper observations in the Kills (to the 99.63 percentile) indicated that an exceedance was exceedingly unlikely. On the other hand, the metals model developed under the initial phase of the Harbor Estuary Program (HEP) indicated that there was a potential to exceed the copper water quality criterion (5.6 μg/L) in the Kills.

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TABLE 2-1.   TOTAL AND DISSOLVED (in parentheses) COPPER CONCENTRATIONS IN SAMPLES TAKEN FROM THE ARTHUR KILL/KILL VAN KULL REGION FOR THE AMBIENT DRY WEATHER MONITORING FROM MAY, 1997 THROUGH OCTOBER, 1997.

Site	Total & (dissolved) Copper $(\mu g/L)^{a,b}$					
	May 97'	Jun 97'	Jul 97'	Aug 97'	Sep 97'	Oct 97'
Station A3	L(L)	3.6(1.6)	L(7^c)	12(L)	3(L)	L(L)
Re-Analysis [d]		4.4(2.4)				
Station 106	L(L)	7.0(2.8)	L(5^c)	7(L)	10(L)	8(5)
Re-Analysis [d]		8.6(3.4)				8.7(8.0)
Station K1	L(L)	3.8(---)	L(L)	L(L)	L(L)	L(L)
Re-Analysis [d]		6.4(2.1)				
Station K2	L(L)	---(1.3)	$4^c(7^c)$	L(L)	L(L)	L(L)
Re-Analysis [d]		6.4(1.6)	3.5(2.4)			

[a] L= reporting limit of 2 $\mu g/L$.

[b] Surface water quality standard for dissolved copper = 5.6 $\mu g/L$.

[c] Estimated values that do not meet QA/QC acceptance criteria.

[d] Re-Analysis of same sample by Battelle Ocean Sciences

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TABLE 2-2.   DISSOLVED COPPER CONCENTRATIONS (μg/L) IN SAMPLES TAKEN FROM THE ARTHUR KILL/KILL VAN KULL REGION FOR THE AMBIENT WET WEATHER MONITORING IN NOVEMBER 1997.

Site	Dissolved Copper (μg/L)[a,b]		
	24 Nov 97[1]	25 Nov 97[1]	26 Nov 97[1]
Station A3	3.20	2.78)[c]	3.39[c]
		(3.67)	(3.38)
Station 106	2.71)[c]	4.75 [c]	2.33[c]
	(2.80)	(2.38)	(4.45)
Station K1	2.43)[c]	2.81 [c]	5.34[c]
	(2.13)	(2.41)	(4.04)
Station K2	2.82)[c]	2.01 [c]	2.68[c]
	(4.08)	(2.71)	(2.87)

[a] L = reporting limit of 2 μg/L.

[b] Surface water quality standard for dissolved copper = 5.6 μg/L.

[c] Samples above and below one another are the concentrations of consecutive morning and afternoon samples, respectively, from the same day.

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TABLE 2-3.   TOTAL COPPER CONCENTRATIONS FROM THE MUNICIPAL WASTEWATER TREATMENT PLANT MONITORING FROM MAY, 1997 THROUGH OCTOBER, 1997. ALL CONCENTRATIONS ARE REPORTED IN μg/L.

Metal Analyzed & WWTP	Month Sampled [a]					
	May 97'	Jun 97'	Jul 97'	Aug 97'	Sep 97'	Oct 97'
Total Copper						
Rahway Valley	35	27	6	8	10	36
Linden-Roselle	7	2	7	13	13	15
Joint Meeting	L	10	6	7	8	7
N. Bergen	14	18[b]	21	18	18	19
Secaucus	13[b]	11	13	14	17	33
Bergen Co.[c]	10 - 12	9 - 7[b]	13	16	20	18

[a] L= reporting limit of 2 μg/L.

[b] Indicates samples analyzed for the purpose of QA/QC.

[c] Values separated by a dash indicate the concentrations of bi-weekly samples for the same month.

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TABLE 2-4.   TOTAL AND DISSOLVED (in parentheses) COPPER CONCENTRATIONS FROM THE CSO SAMPLING FROM JULY, 1997 THROUGH FEBRUARY, 1997.

Site	Date Sampled				
	24 Jul 97	14 Nov 97	22 Nov 97	2 Feb 98	23 Feb 98
	Total (Dissolved) Copper (μg/L)[*]				
Livingston St.	28(10)				
Worthington Ave.	101 (6)				
Ivy St. Chamber	16(10)				
Kearney St. Bridge	14(4)		10(4)		
Christie St.	18(13)				
Elm St.	8(L)	7(L)	25(3)		
Court St.	20(6)		24(6)	30(12)	88(28)
West Side Rd.		33(L)	4(L)		7(L)
Anderson St.					32(7)

[*] L= reporting limit of 2-3 μg/L.

TABLE 2-5.   TOTAL AND DISSOLVED (in parentheses) COPPER CONCENTRATIONS FROM THE SWO SAMPLING FROM JULY, 1997 THROUGH FEBRUARY, 1998.

Site	Date Sampled				
	24 Jul 97	14 Nov 97	22 Nov 97	2 Feb 98	23 Feb 98
	Total (Dissolved) Copper (μg/L)[a]				
CCI	24(8)	33(16)		40(16)	
NAPP-Greco	11(6)	46(12)		55(7)	21(5)
Smith Marina	28(13)	97(11)			
E. Jersey St.	13(8)		10(7)	28(5)	23(7)
Blanchard St.	17(13)	17(9)			
Elm St.	12(6)	17(3)	14(9)	24(5)	22(9)
Henley Rd.	5(L)		7(5)	10(3)	14(5)
Anderson St.	20(10)		6(L)	9(5)	12(3)
West Side Rd.		17(5)			10(L)

[a] L= reporting limit of 2-3 μg/L.

It is important to recognize, however, that in the original modeling evaluation there were no combined sewer overflow (CSO) or storm water outfall (SWO) data available from New Jersey to use in the model projections. Consequently, measurements taken in New York CSOs and SWOs were used as surrogates for New Jersey data. The present program was conducted to address the inconsistency between the ambient data projections and model evaluations. With the additional data collected in this study, the data evaluation approach was further tested, and the modeling projection was updated using actual data from New Jersey CSOs and SWOs.

Monitoring of Ambient Copper in the Kills

The ambient copper concentrations measured in the monitoring program are presented in Tables 2-1 and 2-2. It is important to recognize that the data points in Table 2-1 footnoted with a "c" are estimated values. EPA-Edison indicated that the estimated values are questionable because of a potential salt water matrix interference problem. Because of this issue, none of the "c" footnoted data points were considered in the subsequent data or modeling analyses.

In an effort to obtain reliable data for the estimated values, a number of the Kills copper samples were also analyzed by Battelle's Ocean Sciences laboratory in Duxbury, Massachusetts. Battelle uses an extraction procedure to perform low level copper measurements, and that procedure is not impacted by salt water interference (in contrast, EPA-Edison utilizes a direct injection approach). Battelle's analytical results for Kills copper samples are separately identified in Table 2-1. As a substitute for the EPA-Edison "c" footnoted copper data, the Battelle measurements were incorporated into all data and modeling analyses.

Much of the data presented in Table 2-1 are represented by an "L", indicating that the measured concentration was lower than the limit of detection for the copper analytical technique used by EPA-Edison. A conservative approach was taken in the interpretation of data represented with an "L". In the data analyses and modeling, all "L" represented data were assigned detection limit values (2 μg/L), which is the highest possible (or worse-case) concentration for the samples.

Ambient Data/Probability Distribution

The ambient copper data collected in this phase of monitoring in the Kills were combined with the ambient copper data collected in the initial monitoring phase performed by EPA to form a

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probability distribution (Figure 2-2). The distribution (solid line) defined by the observations (data points) shown in Figure 1 indicates that there is no probability of exceedance of the copper criterion (5.6 μg/L dissolved) at the 99.63 percentile (the chronic compliance frequency).

There was a single aberrant data point which exceeded the 5.6 copper criterion (7.96 μg/L as measured by Battelle Ocean Sciences, Table 2-1, Oct. '97); based upon its relationship to all the other data, that point appears to be an outlier of the observed distribution. To test this assumption, additional statistical testing of this data point was performed. The statistical analysis which was performed to assess whether the 7.96 observation can be considered an outlier is based on Chauvenet's criterion. According to Chauvenet's criterion, an observation in a sample of size n is rejected if it has a deviation from the mean greater than that corresponding to a 1/(2n) probability. The deviation corresponding to a 1/(2n) probability is equal to the z-score associated with the 2n probability times the standard deviation of the sample. For the Kills dissolved copper data set (n=39), and the 1/(2n) probability is 0.0128, which is the probability of a deviation of at least 2.49 times the standard deviation. For the Kills dissolved copper data presented in Figure 2-2, the standard deviation is 0.2239. Thus, any observation which deviates from the mean by more than 0.56 in logarithmic space is rejected based on Chauvenet's criterion. The observation of 7.96 deviates from the mean of 2.23 by 1.27 in logarithmic space. Thus, according to Chauvenet's criterion, the 7.96 μg/l dissolved copper observation is considered to be an outlier relative to the balance of the observed data.

We believe that this data point is not an accurate reflection of the dissolved copper concentration in the Arthur Kill because when the sample was originally analyzed by EPA Edison, a dissolved copper value of 5 μg/L (below the 5.6 μg/L WQS) was obtained, and that value was considered by EPA Edison to be an accurate value. However, after this sample was analyzed by EPA Edison in New Jersey, it was resealed, packed and transported to Battelle Ocean Sciences in Massachusettes, and re-analyzed by Battelle. We believe that the sample became contaminated in the process of sample transfer and re-analysis, and therefore, that 7.96 μg/L is not a realistic representation of the ambient copper concentration in the Arthur Kill.

In spite of the fact that it is clear that the 7.96 μg/L value is an outlier, that value was included in the probability distribution in Figure 2-2, and that distribution showed that there was no probability of exceedance of the copper criterion. This outcome further supports the conclusion that the 7.96 μg/L value is an outlier data point.

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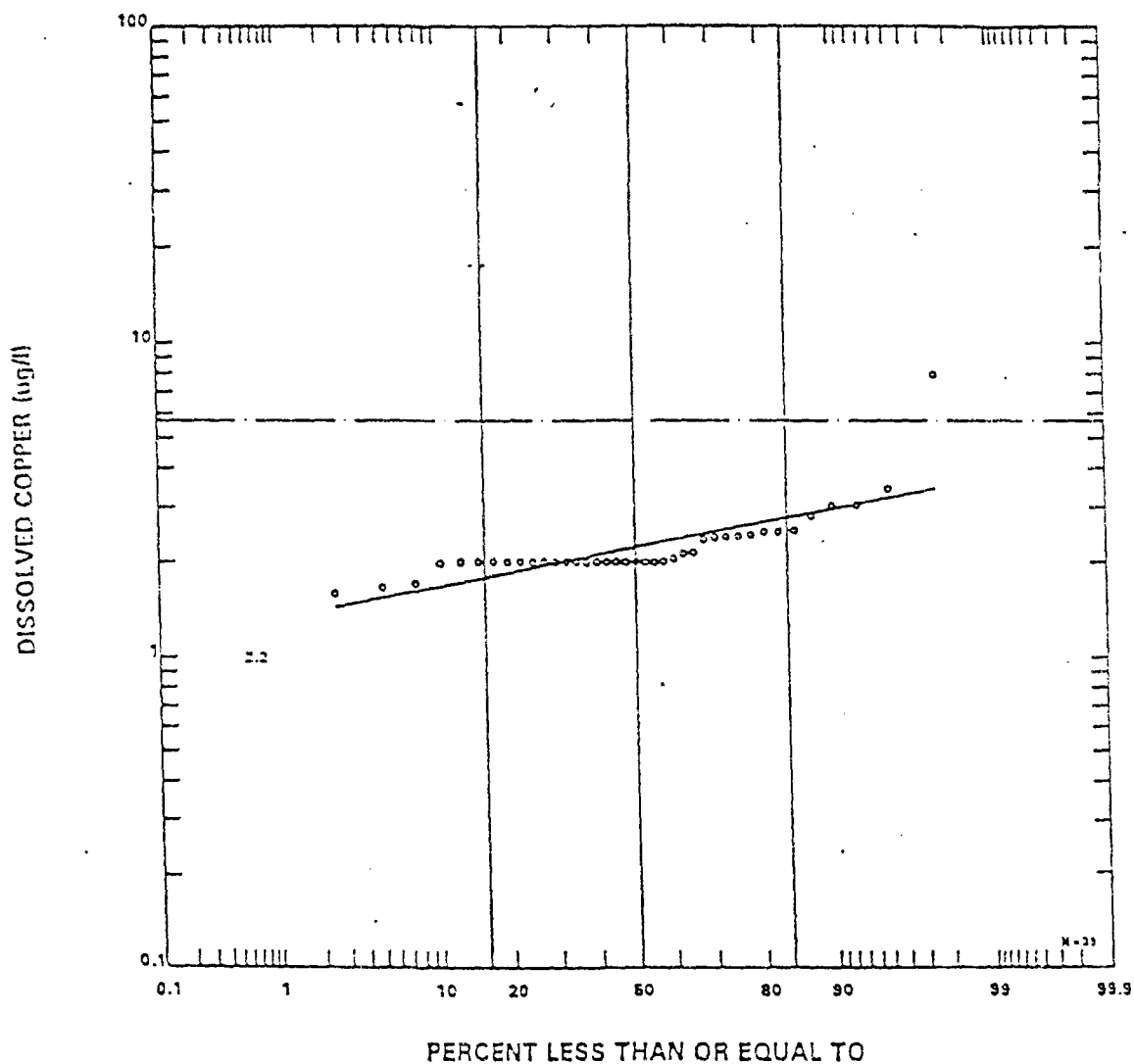
Figure 2-2.   Arthur Kill and Kill Van Kull ambient dissolved
               copper data collected by EPA and the New Jersey
               Harbor Dischargers Group

The sampling program coordinated by NJHDG with EPA-Edison also included a New Jersey POTW, CSO and SWO sampling component. The objective of this sampling effort was to provide the direct measurements of total copper concentrations in New Jersey's CSOs and SWOs that were not available for the initial modeling effort, and to obtain more current New Jersey POTW copper data. The CSO and SWO copper measurements were then used to develop probability distributions to determine a likely estimate of copper concentrations in New Jersey CSOs and SWOs for use in revising the model projections. The probability distributions are shown in **Figures 2-3** and **2-4**.

The dissolved copper unit response matrix developed during the initial modeling effort was then revised utilizing the actual New Jersey copper concentrations for CSOs and SWOs. The dissolved copper unit response matrix has also been revised to include a new long-term average (LTA) goal for model results in the Kills. Originally, the LTA goal for the Kills (3.24 μg/l dissolved) was based on the slope of the probability distribution underlying the Kills ambient dissolved copper measurements collected in EPA's original monitoring effort, and the chronic copper criterion of 5.6 μg/l. The new LTA goal for the Kills (3.15 μg/l dissolved) is based on the slope of the probability distribution underlying a hybrid of copper data collected during the present and the previous phases of monitoring, as shown in **Figure 2-4**. The unit response matrix was executed with the New Jersey CSO concentration specified as 19.1 μg/l, as opposed to the original (New York) value of 152.9 μg/l, and the New Jersey SWO concentration specified as 17.5 μg/l, as opposed to the original value of 66.6 μg/l. The result of these changes in the matrix lowered the range of projected dissolved ambient copper concentrations in the Kills model segments from 2.75 - 4.37 μg/l (which was a contravention of both the original and new LTA goals), to 2.15 - 2.96 μg/l, which is in compliance with both LTA goals.

Values assigned to other loads in this sensitivity calculation of the unit response matrix are summarized in **Table 2-6**. It should be noted that the dissolved copper unit response matrix is a simplified predictive tool that was developed based upon the full harbor-wide copper model. In the copper unit response matrix, copper concentrations are not assigned to individual loads, as in a full model simulation, but to groups of loads. For this reason, the unit response matrix results may not be as precise as a full model simulation. For example, in the unit response matrix , the three POTWs
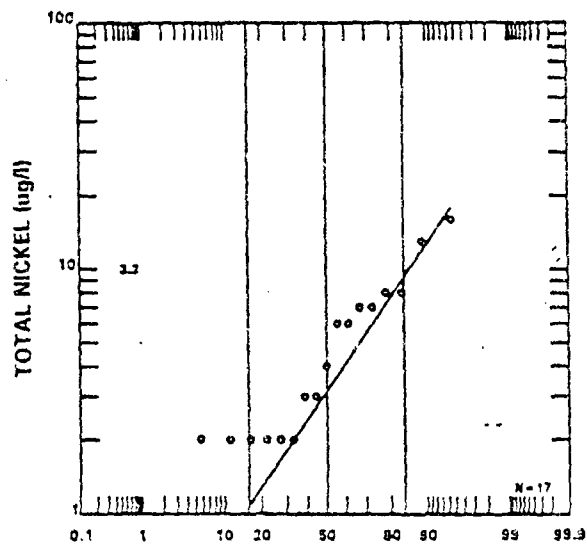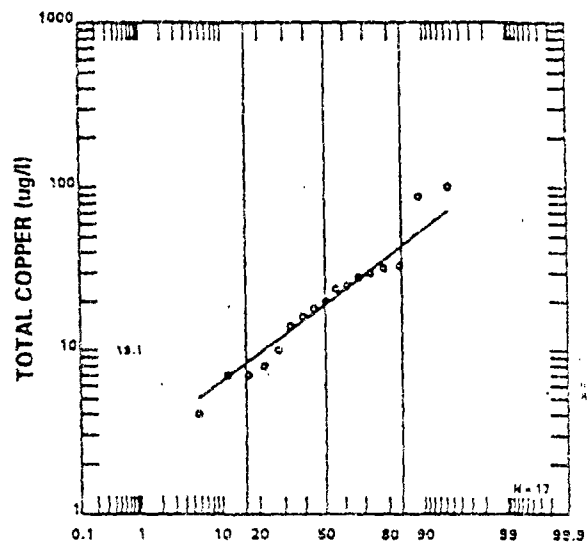
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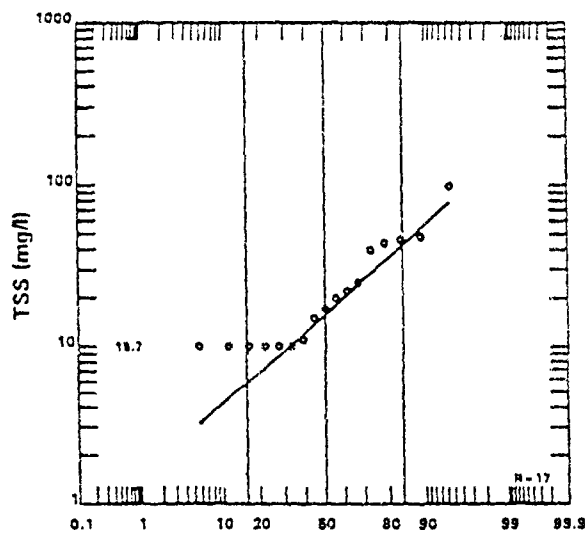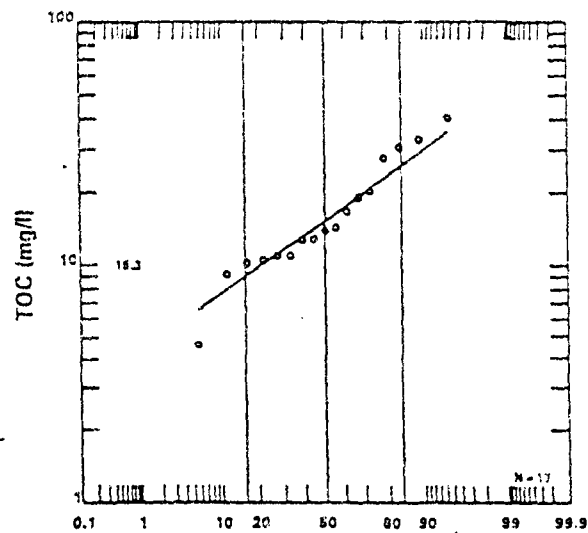
Figure 2-3   CSO concentrations measured during the present Phase II monitoring program
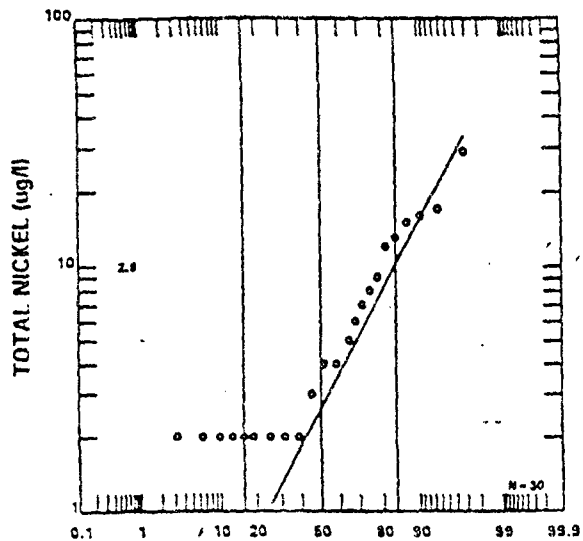
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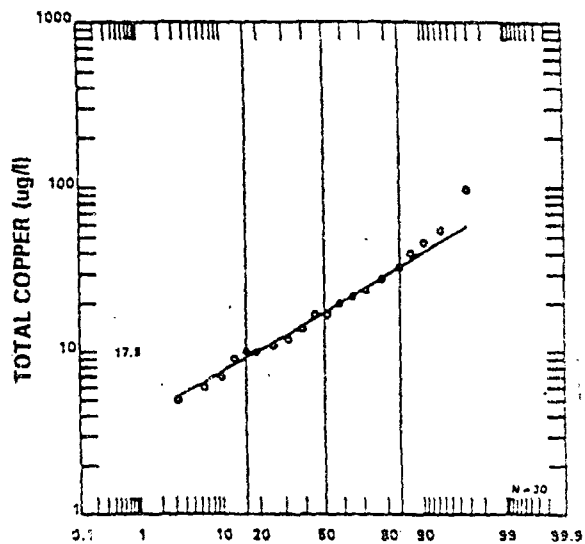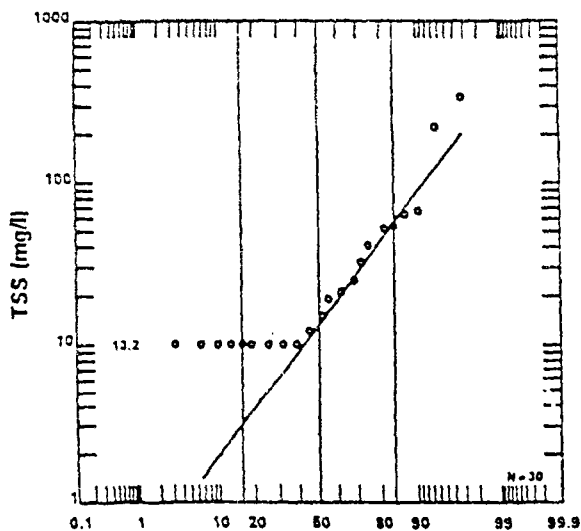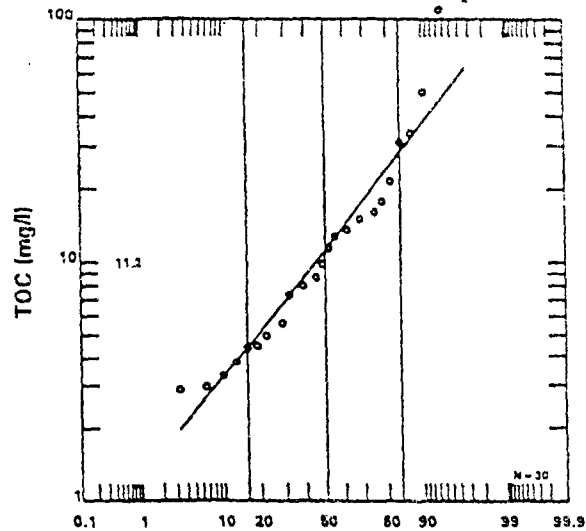
Figure 2-4   SWO concentrations measured during the present
              Phase II monitoring program

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Table 2-6 Concentrations Assigned in The Copper Unit Response Matrix for The Revised New Jersey CSO and SWO Sensitivity Run	
LOADING SOURCE	TOTAL COPPER (μg/L)
Hudson River POTWs	23.6
Upper Bay POTWs	23.6
Outer Harbor POTWs	23.6
Kills POTWs	23.6
East River POTWs	23.6
Jamaica Bay POTWs	23.6
Raritan River and Bay POTWs	23.6
Hackensack, Passaic, and Newark Bay POTWs	23.6
NY CSOs	152.9
NY SWOs	66.6
NJ CSOs	19.1
NJ SWOs	17.5
Hudson River Boundary	3.7
Hackensack River Boundary	6.2
Passaic River Boundary	5.0
Raritan River Boundary	2.8

discharging to the Kills are grouped together, and are assigned a single effluent copper concentration. In the unit response matrix application detailed in **Table 2-6**, a single effluent copper concentration of 23.6 μg/l was used for the Kills POTWs. In the more detailed full model simulation performed in October 1991 (upon which the matrix is based), the 3 POTWs discharging to the Kills were not grouped together, and individual effluent copper concentrations of 17.7, 10.2, and 23.6 were used (Table 2-7). **Figures 2-5** and **2-6** demonstrate the high level of precision of the full model. The full model calculations using individual effluent copper concentrations agree well with observed total and dissolved ambient copper data for both January and October 1991.

In **Figures 2-5** and **2-6**, model results and data are presented along a spatial transect of the Kills. The Kills transect runs from the Arthur Kill at its confluence with Raritan Bay (mile 18.2), clockwise ; around Staten Island, and through the Kill Van Kull, ending at the confluence of the Kill Van Kull and the Upper Bay (mile 0). The lower panels of **Figures 2-5** and **2-6** are of particular interest, as these panels show the dissolved copper model and data comparisons. Values assigned to other loads in this sensitivity calculation of the unit response matrix are summarized in **Table 2-6**.

The full model runs described above were conducted for both January 1991 and October 1991 conditions to confirm the unit response matrix results. All loads used in the full model simulations for January 1991 and October 1991 are those which were agreed upon by EPA Region II and the States of New York and New Jersey during the development of the model. These loads are documented in reports issued previously by HydroQual, Inc. The only change to the loads for the projections presented in this report is that the revised (actual) New Jersey CSO and SWO concentrations have been used. **Figure 2-7** shows the dissolved copper results for both 1991 model simulation periods. Note on **Figure 2-7** that the model computed dissolved copper concentrations less than the LTA goal of 3.15 μg/L consistently over the entire length of the Kills transect for both January and October 1991 conditions. These model results are in agreement with the unit response matrix results, and the statistical projection of ambient data, further supporting the conclusion that the chronic dissolved copper criterion of 5.6 μg/L is not likely to be exceeded in the Kills, and that there is no need for TMDLs for copper in the Kills.

In addition to the New Jersey CSO and SWO sampling component of this study, the sampling program coordinated by the NJHDG with EPA-Edison also included effluent monitoring at the Linden Roselle, Joint Meeting of Essex/Union Counties, and Rahway Valley POTWs. Effluent copper was measured at these facilities discharging to the Kills on six occassions between May 1997 and October

Table 2-7			
Effluent Copper Measurements [in μg/L] at STPs Discharging to the Kills and the Hackensack River			
STP	January 1991	October 1991	May - October 1997
Linden Roselle	31.1	17.7	2 - 15
Joint Meeting Essex/Union Counties	29.1	10.2	< 2 - 10
Rahway Valley	28.4	23.6	6 - 36
North Bergen	23.6[1]	23.6[1]	14 - 21
Bergen County	47.0	21.3	9 - 20
Secaucus	23.6[1]	23.6[1]	11 - 33

Notes:

[1]Estimated value
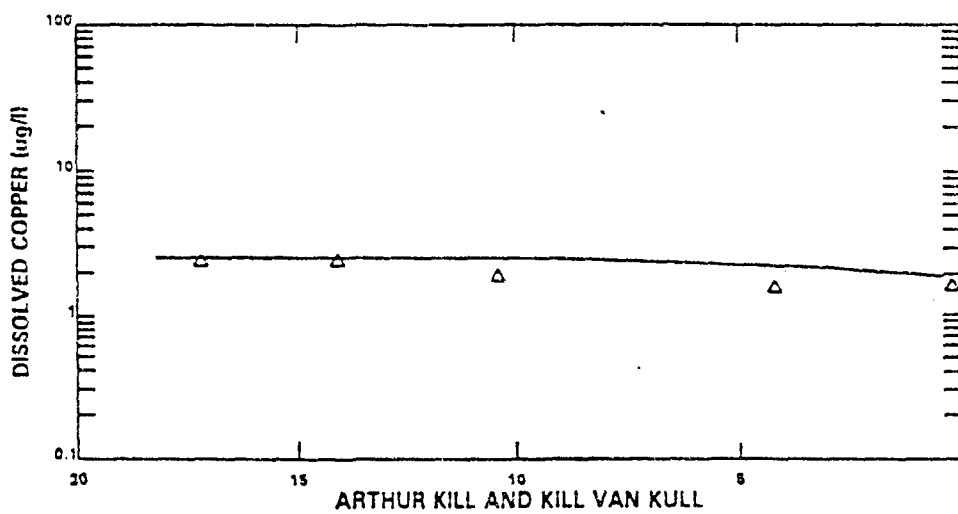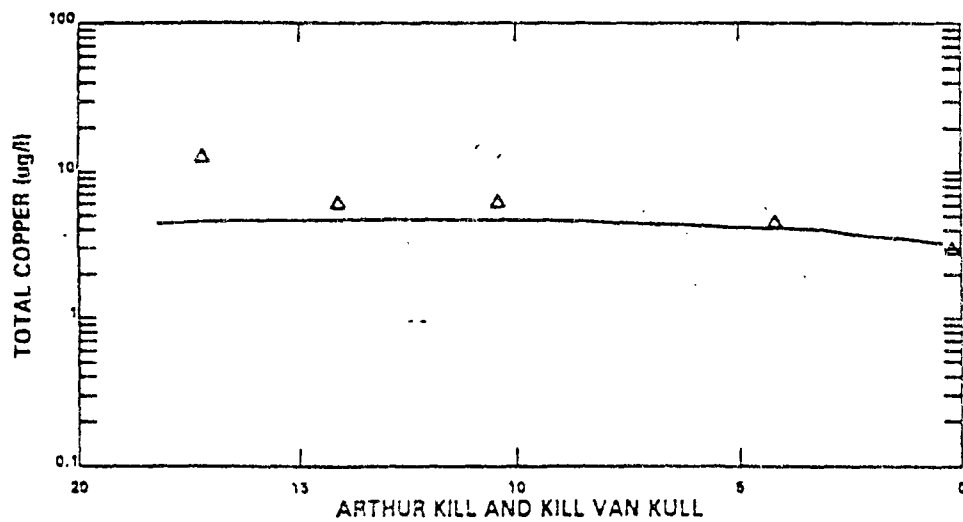
Figure 2-5   January 1991 model calibration with revised NJ CSO
               + SWO copper loads   37
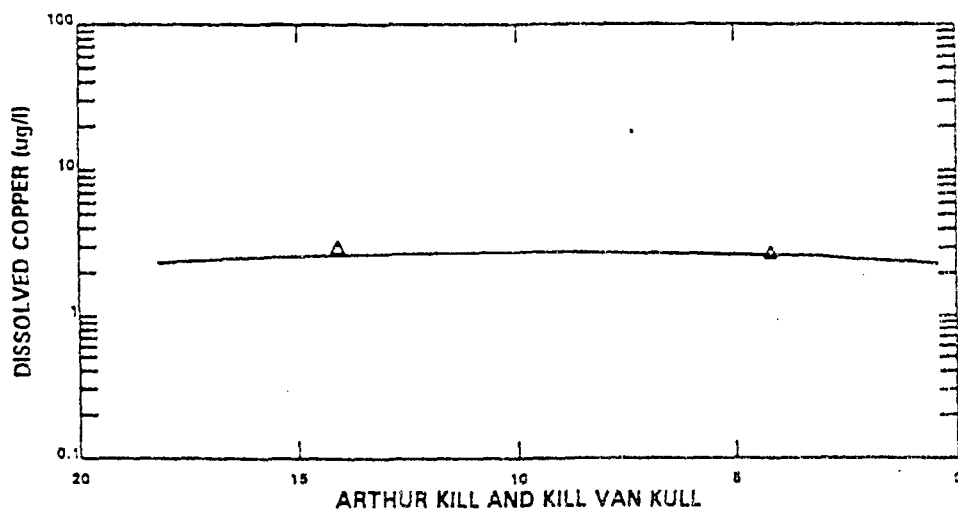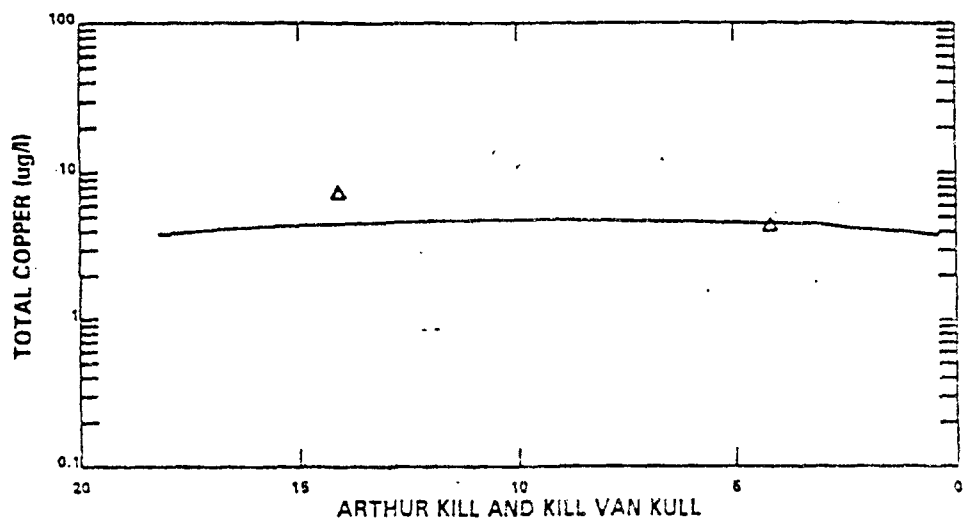
Figure 2-6   October 1991 model calibration with revised NJ CSO
                + SWO copper loads

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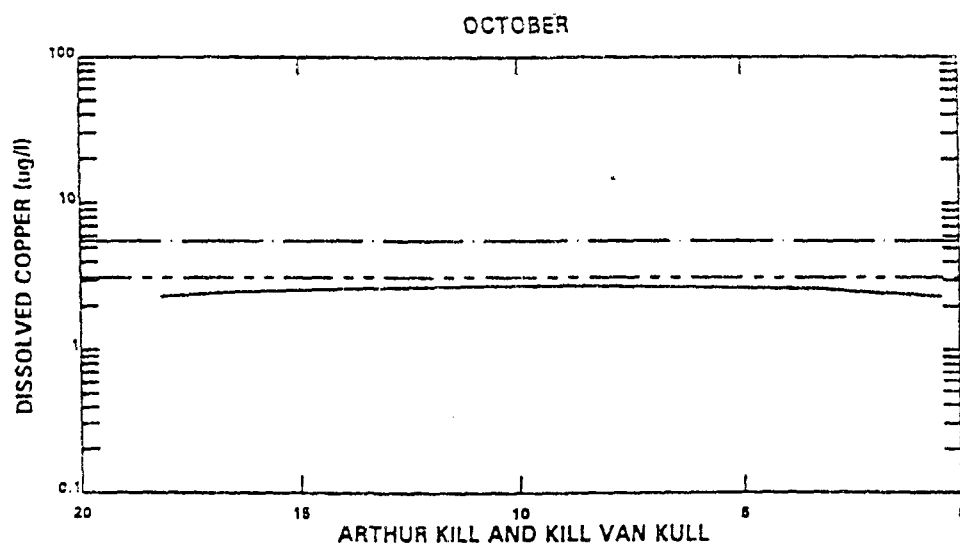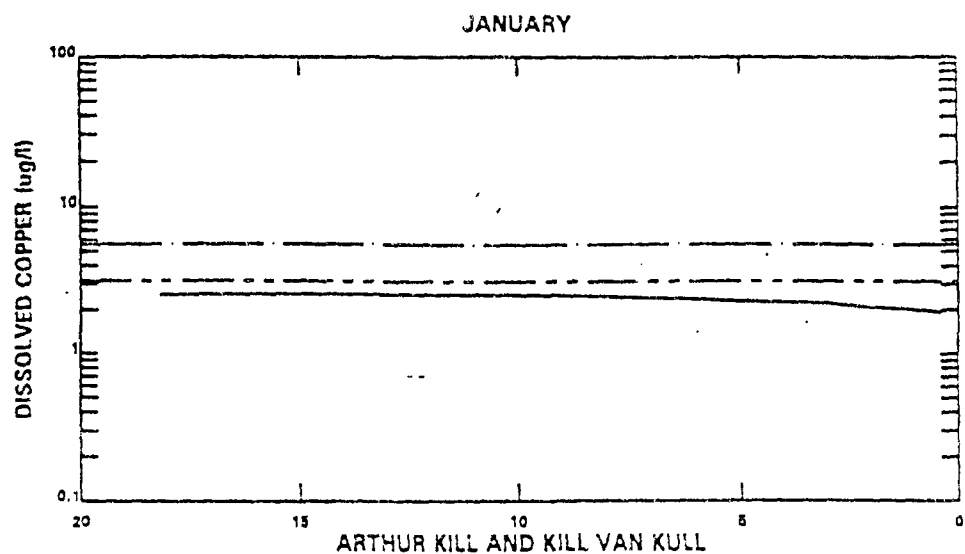
Figure 2-7   January and October 1991 comparison of model results to long term average goal

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1997, as summarized in **Table 2-3**. Over the same period, EPA-Edison also monitored effluent copper concentrations on 6 to 12 occassions at the North Bergen, Bergen County Utilities Authority, and Secaucus POTWs, which discharge to the Hackensack River, as also summarized in **Table 2-3**. In **Table 2-7** we have summarized the effluent copper concentrations measured at these facilities during 1991, and compared those values to those obtained in the present study. It is obvious from the 1991 and 1997 data comparison that the New Jersey POTW effluent copper concentrations have decreased (in some cases dramatically) in recent years. These reductions in copper concentrations are likely the result of the complete implementation of effective industrial pretreatment programs at the New Jersey POTWs, and of improved treatment efficiency at those plants.

Recall that for both the unit response matrix and full model simulations discussed above, the higher 1991 STP effluent copper concentrations were used. If the unit response matrix and model simulations were to be repeated using the lower 1997 STP effluent copper concentrations, as opposed to the higher 1991 values, the margin of safety for achieving the LTA goal of 3.15 μg/L would be even higher than was projected.

In conclusion, both ambient data collected in the New Jersey tributary metals monitoring program, and the revised model projections indicate that the chronic dissolved copper criterion of 5.6 μg/L is not likely to be exceeded in the Kills. Therefore, it is obvious that there is no need for TMDLs for copper in the Kills.
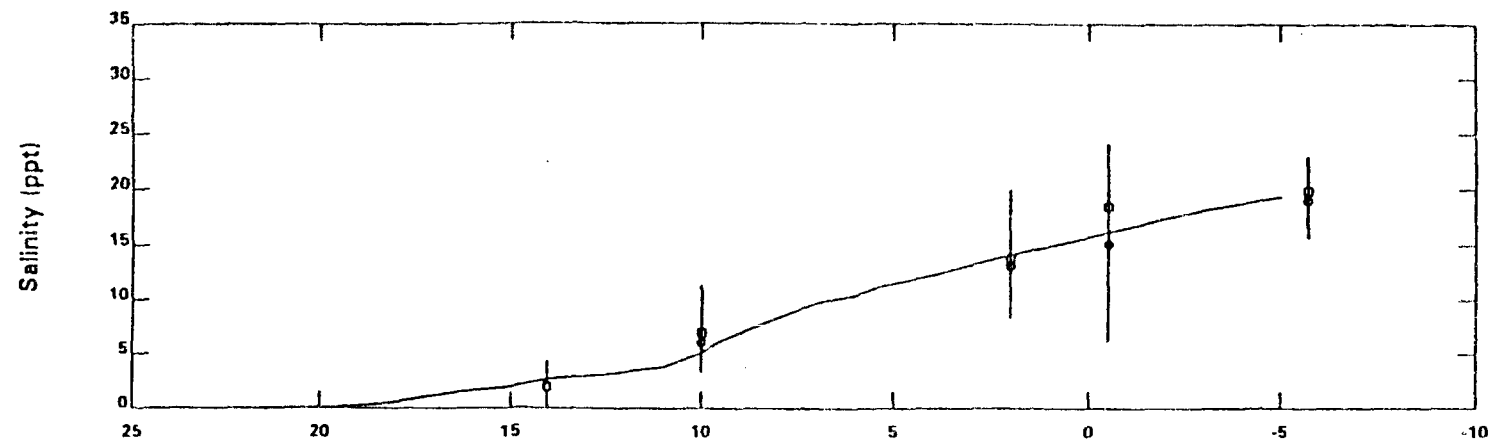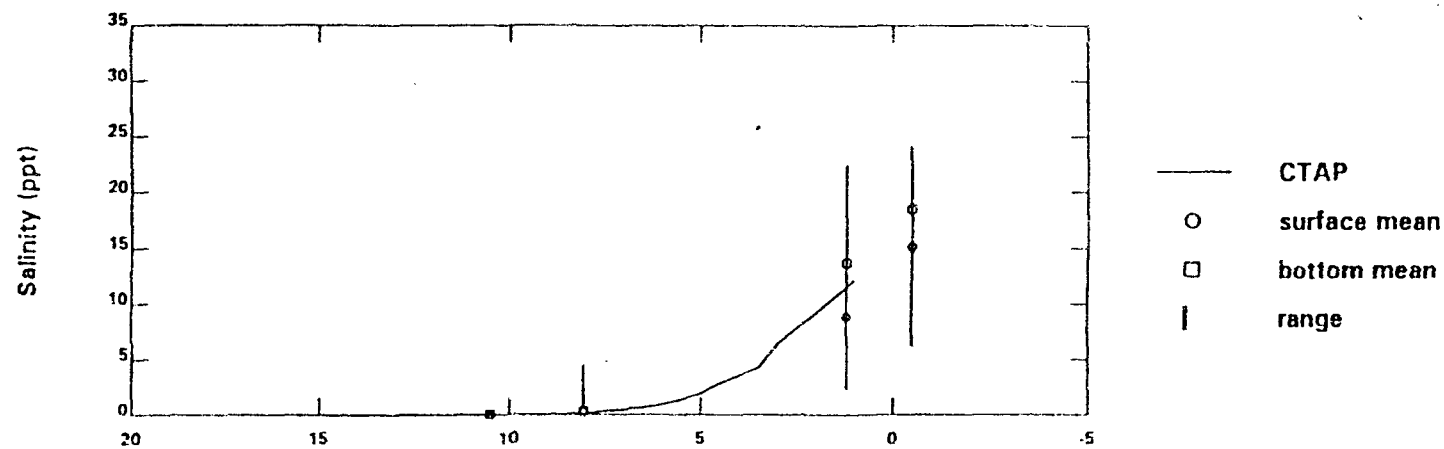
APPENDIX A

MODELING CALIBRATION FIGURES
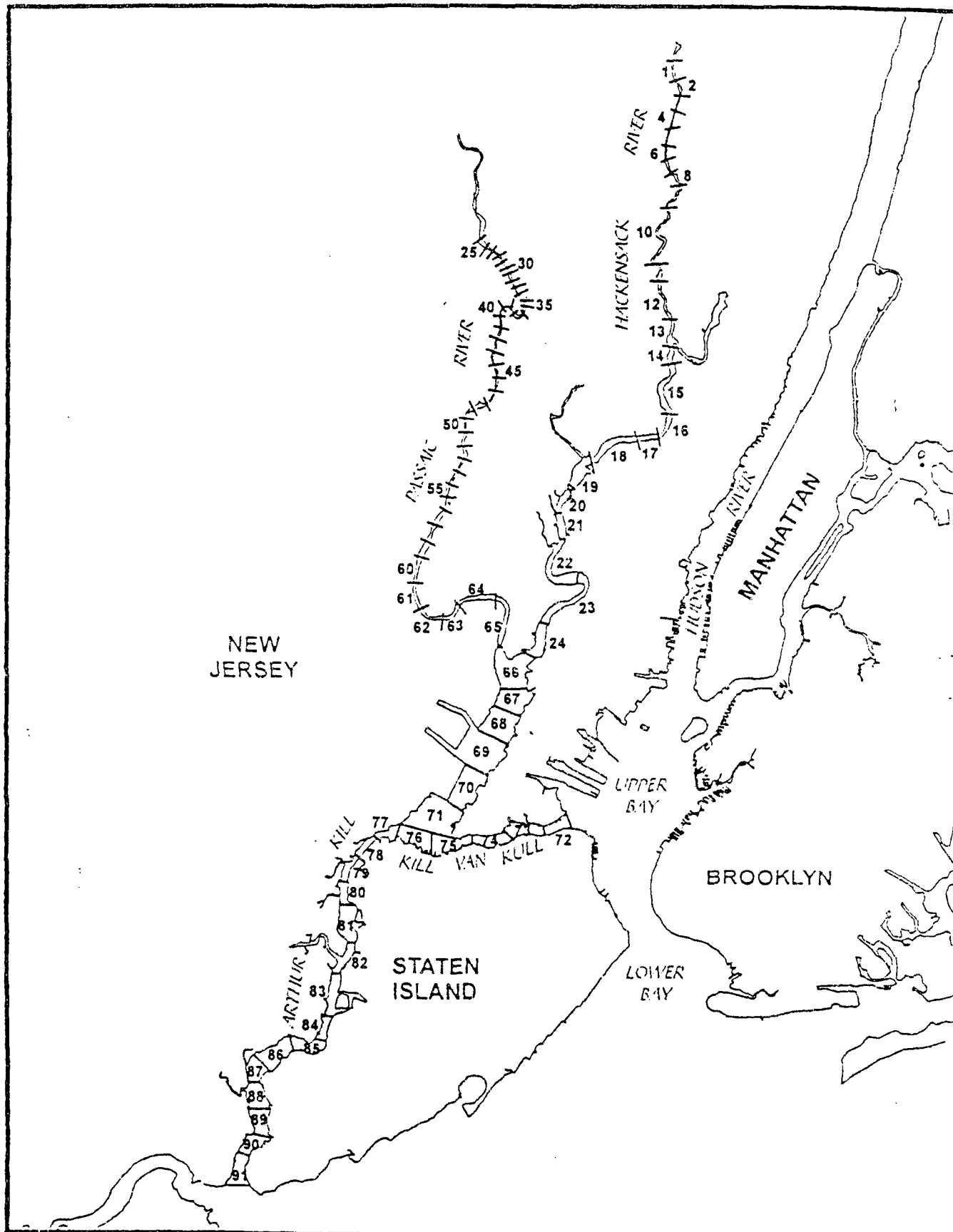
FIGURE A-1
SCHEMATIC OF MODEL SEGMENTATION

COMPARISON OF CALCULATED AND MEASURED SALINITY
APRIL 1997 - FEBRUARY 1998

FIGURE A-2

946550048
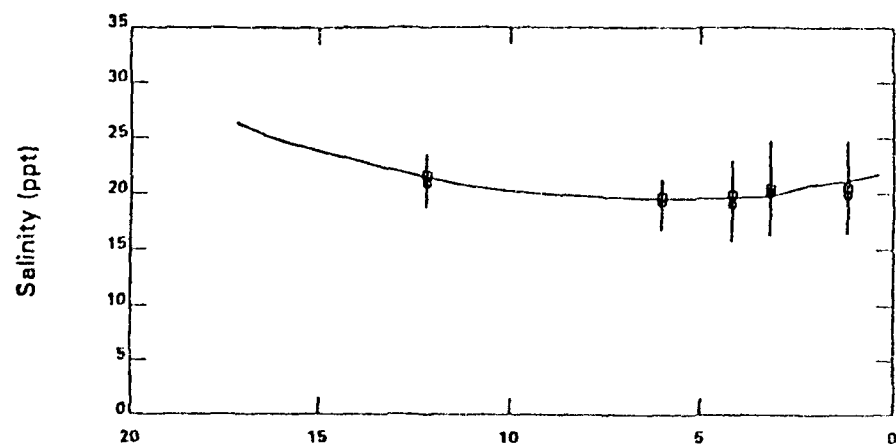
COMPARISON OF CALCULATED AND MEASURED SALINITY
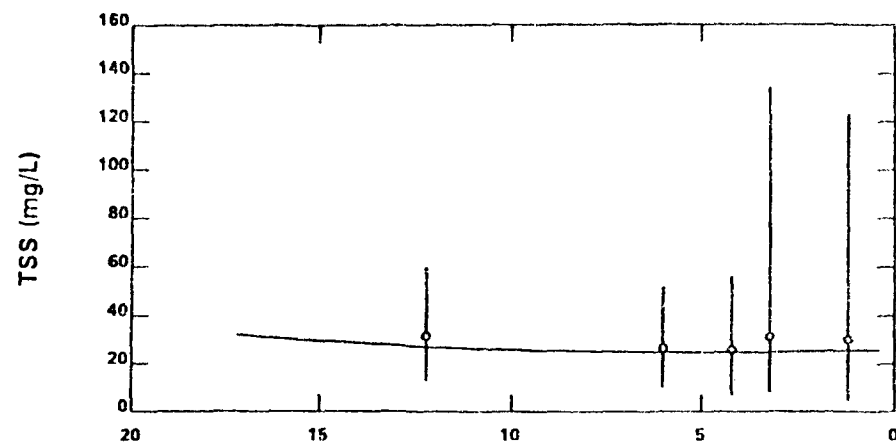APRIL 1997 - FEBRUARY 1998

FIGURE A-3

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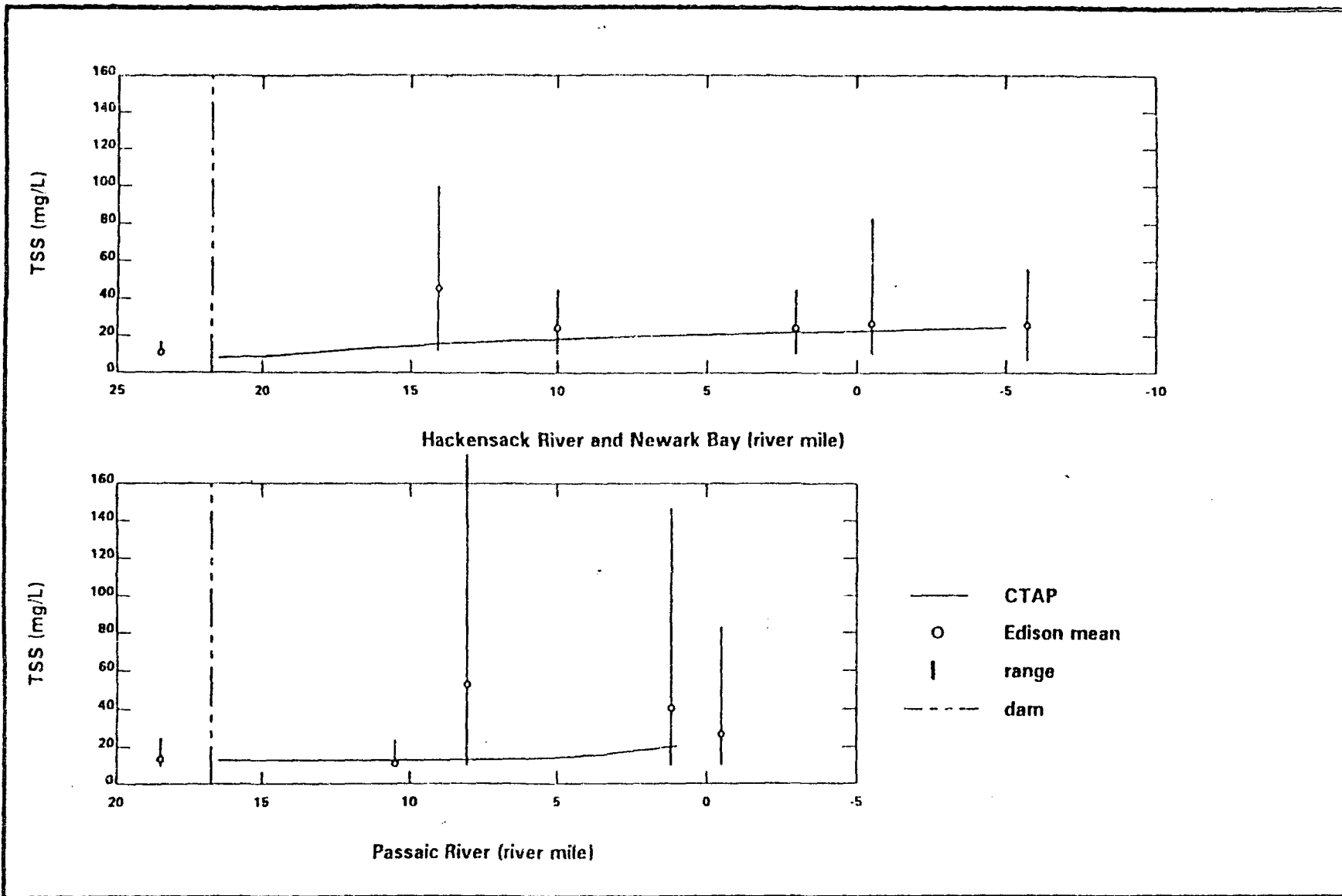
COMPARISON OF CALCULATED AND MEASURED SUSPENDED SOLIDS
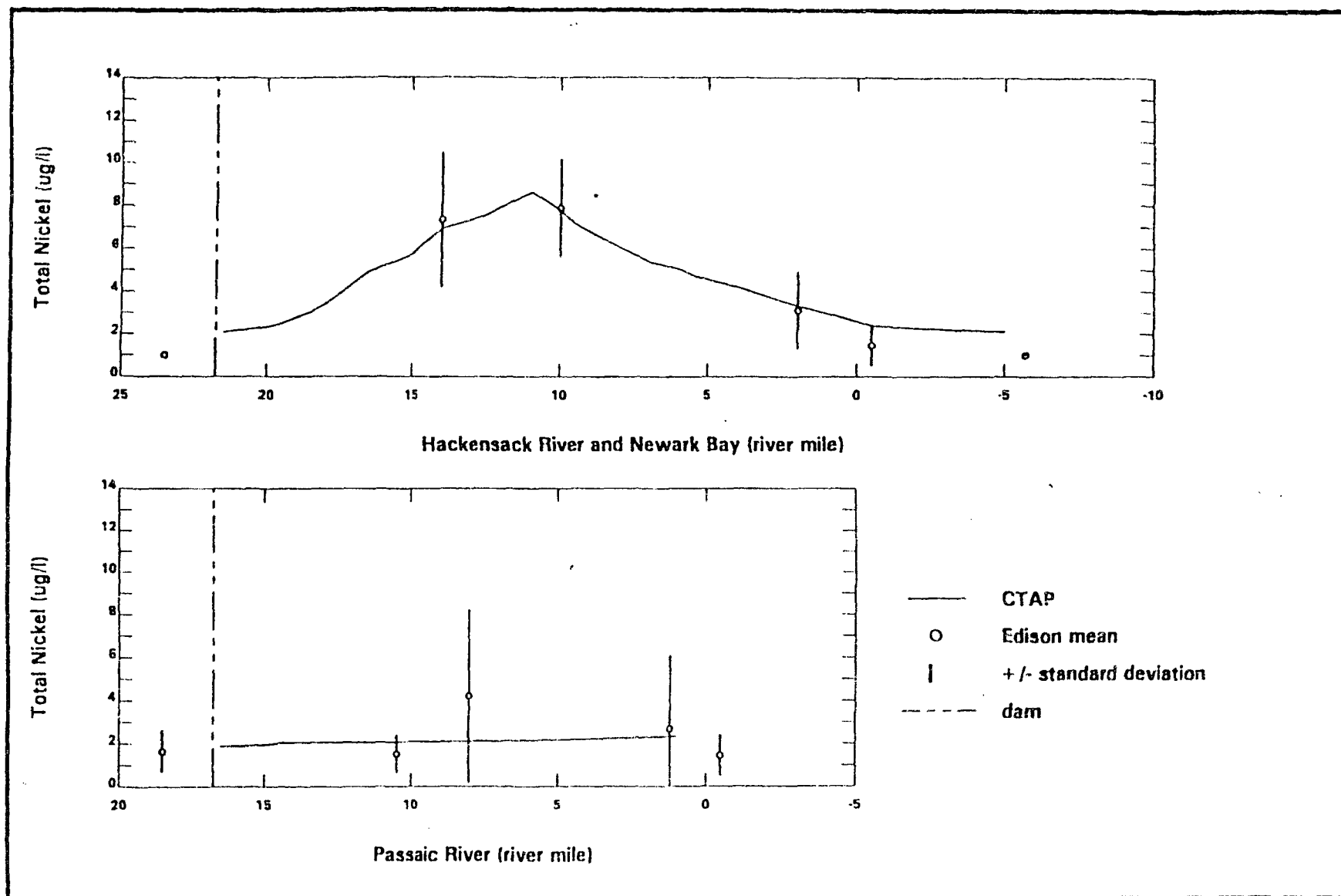APRIL 1997 - FEBRUARY 1998

FIGURE A-4

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COMPARISON OF CALCULATED AND MEASURED SUSPENDED SOLIDS
APRIL 1997 - FEBRUARY 1998

FIGURE A-5

COMPARISON OF CALCULATED AND MEASURED TOTAL RECOVERABLE NICKEL
APRIL 1997 - FEBRUARY 1998
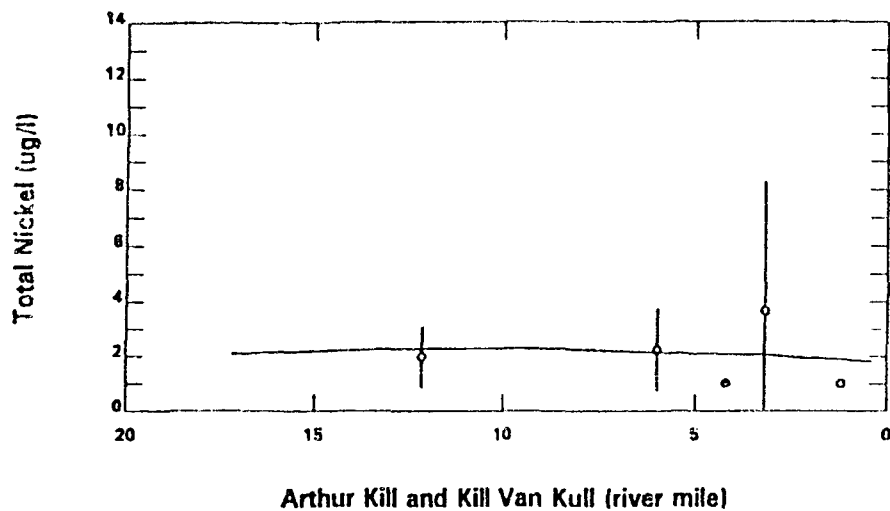
FIGURE A-6

COMPARISON OF CALCULATED AND MEASURED TOTAL RECOVERABLE NICKEL
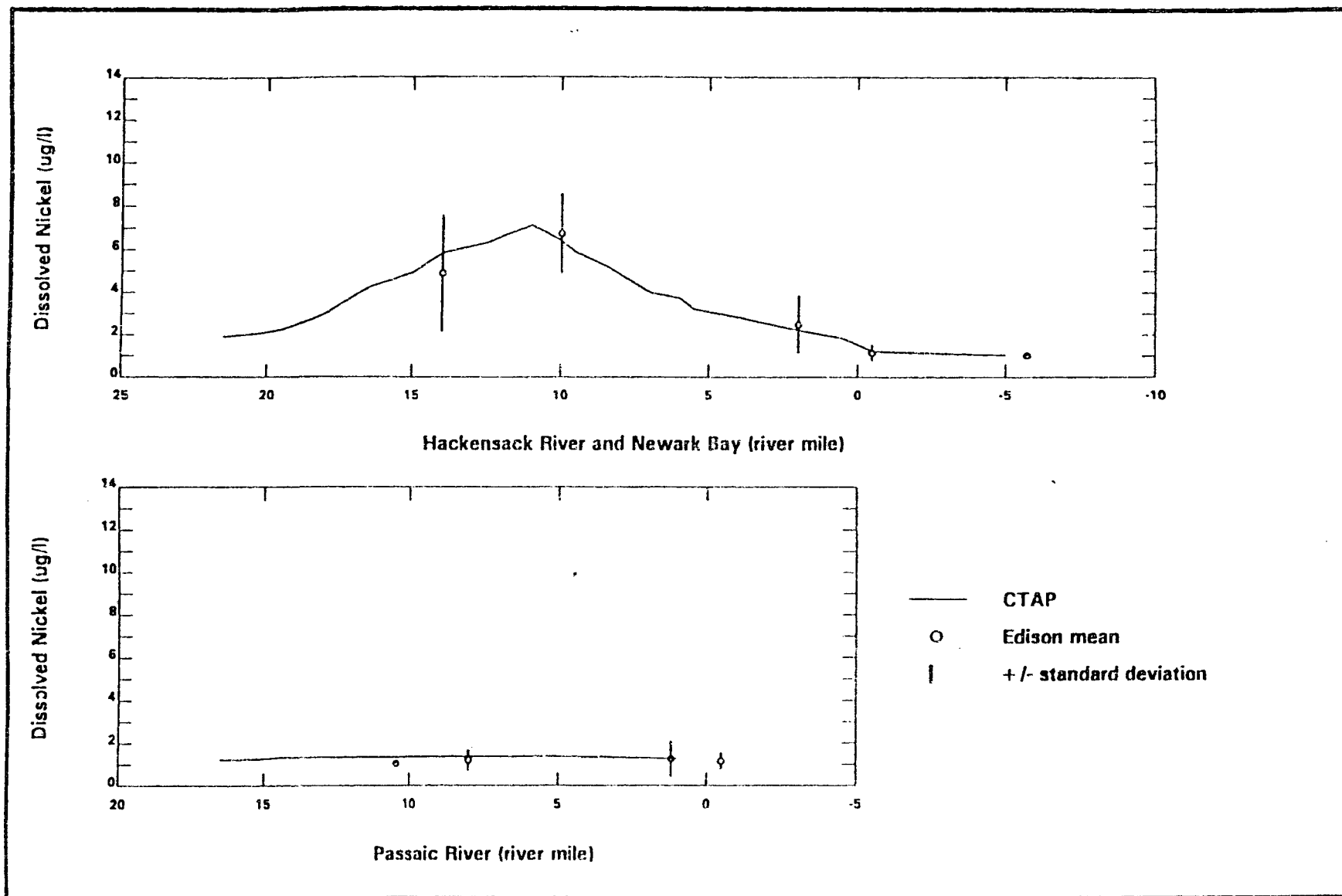APRIL 1997 - FEBRUARY 1998

FIGURE A-7

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COMPARISON OF CALCULATED AND MEASURED DISSOLVED NICKEL
APRIL 1997 - FEBRUARY 1998

FIGURE A-8

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